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University of Tennessee Agricultural Experiment Station

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TWENTY-SIXTH ANNUAL REPORT

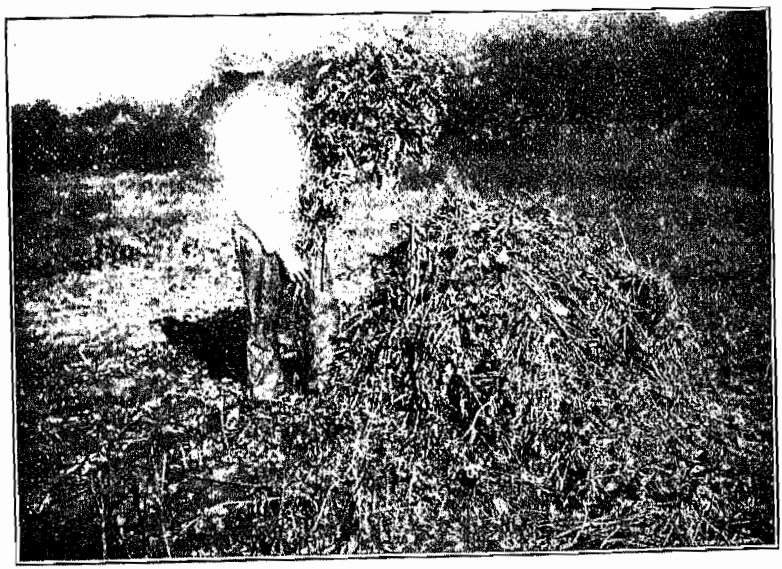
OF THE

Agricultural Experiment Station

OF THE

UNIVERSITY OF TENNESSEE

FOR 1913



SOY-BEAN HAY GROWN ON "NATURAL MEADOW"

A rich-looking but sour soil, on which most crops fail

KNOXVILLE, TENNESSEE

The Agricultural Experiment Station
OF THE UNIVERSITY OF TENNESSEE

BROWN AYRES, President

EXPERIMENT STATION COMMITTEE

BROWN AYRES — J. E. HITE
SAMUEL N. WARREN — I. B. TIGRETT

TREASURER
JAMES MAYNARD

SECRETARY
WM. RULE

STATION OFFICERS

BROWN AYRES, President of the University
H. A. MORGAN, Director, Zoologist and Entomologist
S. M. BAIN, Botanist
C. A. MOOERS, Chemist and Agronomist
C. A. KEFFER, Horticulturist
M. JACOB, Veterinarian
C. A. WILLSON, Animal Husbandman
S. H. ESSARY, Assistant Botanist and Mycologist
G. M. BENTLEY, Assistant Zoologist and Entomologist
MAURICE MULVANIA, Bacteriologist
E. C. COTTON, Assistant Entomologist
J. F. VOORHEES, Consulting Meteorologist
W. H. MACINTIRE, Soil Chemist
J. I. HARDY, Assistant Chemist
L. G. WILLIS, Assistant Chemist
RUSSELL G. BRIGGS, Assistant Horticulturist
W. A. CAMPBELL, Farm Foreman
S. M. SPANGLER, Assistant in Plot Work
J. E. CONVERSE, Assistant in Cooperative Experiments, Crossville
W. N. RUDD, Assistant in Cooperative Experiments, McMinnville
L. R. NEEL, Assistant in Cooperative Experiments, Nashville
S. A. ROBERT, Supt. West Tenn. Exp. Station, Jackson
F. H. BROOME, Librarian and Secretary
MISS RUBY FRANKLIN, Office Assistant
MISS MARGARET COOMES, Stenographer

The Experiment Station building, containing the offices and laboratories, and the plant house and part of the Horticultural Department, are located on the University campus, 15 minutes' walk from the Custom House in Knoxville. The experiment farm, the barns, stables, dairy building, etc., are located one mile west of the University on the Kingston Pike. The fruit farm is adjacent to the Industrial School and is easily reached by the Lonsdale car line. Farmers are cordially invited to visit the buildings and experimental grounds.

Bulletins of this Station will be sent, upon application, free of charge, to any farmer in the State.

LETTER OF TRANSMITTAL

KNOXVILLE, TENN., January I, 1914

To His Excellency, Ben W. Hooper, Governor of Tennessee.

Sir: I have the honor to transmit herewith, on behalf of the Board of Trustees of the University of Tennessee, a report of the work and expenditures of the Agricultural Experiment Station for the year 1913. This report is submitted in accordance with the law requiring that the Board having direction of the Experiment Station shall annually submit to the Governor of the State a report of its operations and expenses.

Very respectfully,

BROWN AYRES, President.

The University of Tennessee Agricultural Experiment Station

IN ACCOUNT WITH

THE UNITED STATES APPROPRIATIONS, 1912-1913

	Hatch Fund	Adams Fund
To United States Treasury Drafts	$15,000.00	$15,000.00
By Salaries	8,940.00	11,113.33
Labor	2,356.29	736.45
Publications	474.39	
Postage and stationery	320.89	5.01
Freight and express	111.90	125.62
Heat, light, water and power	501.31	78.97
Chemicals and laboratory supplies	171.28	462.89
Seeds, plants and sundry supplies	347.19	285.72
Fertilizers	179.50	15.78
Feeding stuffs	827.07	
Library	186.61	147.11
Tools, machinery, and appliances	314.31	226.23
Furniture and fixtures	87.35	462.81
Scientific apparatus and specimens	83.50	1,048.36
Live stock		
Traveling expenses	52.95	90.66
Contingent expenses	20.00	
Buildings and land	25.46	201.06
Balance		
Total	$15,000.00	$15,000.00

We, the undersigned, duly appointed Auditors of the Corporation, do hereby certify that we have examined the books and accounts of the University of Tennessee Agricultural Experiment Station for the fiscal year ended June 30, 1913; that we have found the same well kept and classified as above; that no balances were brought forward from the preceding year on the Hatch and Adams Funds; that the receipts for the year from the Treasurer of the United States were $15,000.00 under the act of Congress of March 2, 1887, and $15,000.00 under the act of Congress of March 16, 1906, and the corresponding disbursements $15,000.00 and $15,000.00; for all of which proper vouchers are on file and have been by us examined and found correct.

And we further certify that the expenditures have been solely for the purposes set forth in the acts of Congress approved March 2, 1887, and March 16, 1906, and in accordance with the terms of said acts, respectively.

Signed:

BROWN AYRES
HU L. McCLUNG
JAMES MAYNARD
Auditors.

Attest:
WM. RULE, Custodian.

TWENTY-SIXTH ANNUAL REPORT OF THE AGRICULTURAL EXPERIMENT STATION OF THE UNIVERSITY OF TENNESSEE FOR 1913

REPORT OF THE DIRECTOR

To President Brown Ayres:

Most of the experimental projects upon which past reports were made have been continued. They have embraced laboratory and field work in soil fertility, crop adaptation, study of plant and animal diseases, insects, soil bacteria, horticultural investigations, the relation of climate to crop production, the relation of systems of cropping to livestock production, and systems of cropping with special reference to the larger introduction of legumes, based upon the use of lime. To these have been added some investigations in the feeding of cottonseed meal to hogs, with and without iron sulphate, and experiments with tobacco, in cooperation with the Bureau of Plant Industry, U. S. Department of Agriculture. The tobacco investigations are to be carried on at Clarksville, and the expenses are to be borne in part by the County of Montgomery. They are designed to test tobacco in extensive rotations of various legumes, grasses, and grains. Lime and phosphate form the larger part of the minerals applied.

The Legislature of 1913 reappropriated $5,000 a year for two years for equipment at the West Tennessee Experiment Station, at Jackson. Due to delay of the Commission appointed to locate the Station, one year's maintenance appropriation of $10,000 was returned to the Treasury of the State. On request for additional buildings, and the building of a road through the Station grounds, the amount was reappropriated, to be spent during the biennial period of 1913 and 1914.

Early in 1913, a commission for the study of rural credits and cooperation in European countries was organized, largely through the efforts of the Southern Commercial Congress and Mr. David Lubin, U. S. representative at the International Institute of Agriculture, Rome, Italy. The American Commission was to represent all the states of the Union, and was to cooperate in its studies and investigations with the United States Commission, composed of seven members, appointed by President Wilson. Governor Hooper commissioned the Director of the Experiment Station. The Board of Trustees of the University of Tennessee generously granted him a leave of absence for three months. Leaving the latter part of April, and returning the last of July, he was afforded a splendid opportunity for the study of agricultural conditions in Italy, Hungary, Austria, Germany, Den-

mark, Holland, Belgium, France, England and Ireland. The season of the year was most propitious for observations upon methods of soil improvement, systems of cropping, farm management operations, control of diseases, the relation of dense population to methods of farm practice, crop rotation, and fertilization, and the larger and more permanent problems of rural education and economy. Opportunity was afforded for visits to many of the experiment stations of these countries. The keener competition, and the older and more advanced methods of rural education, have placed the farmers of these countries in more intimate relation with experimental results than in our own country. Cooperation in finance, production, and marketing is well developed and of incalculable value to the agriculture of these older countries. A modification of the system of cooperative credit and cooperative organization will necessarily have to be adapted to American agriculture in the near future.

An Assistant Horticulturist was added to the Experiment Station staff during the year, Russell G. Briggs being appointed to this position. He began work July 1.

R. H. Milton was put in charge of the Tobacco Experiment Station, at Clarksville.

I respectfully call your attention to the reports of the various Station departments. The Station workers have been loyal to the tasks of their projects, and to the relation of the activities of their departments to the farm life of the State.

Respectfully submitted,

H. A. MORGAN, Director.

REPORT OF THE BOTANIST

No additional projects have been begun in this Department the past year.

The selection work for anthracnose-resistance in red clover may be regarded as complete, and it is now only necessary to record the continued success attending the cultivation of this strain of seed in Tennessee. The past season was almost a failure, however, so far as seed production is concerned, and the continued extension of the cultivation of resistant clover must depend on last year's crop.

Considerable time has been devoted during the past year to selection work with resistant clover, looking toward its improvement along other lines than disease-resistance.

Experiments have been continued the past year in the study of the general subject of disease-resistance. A number of interesting lines of investigation have opened up, but nothing sufficiently definite for publication. In the course of these investigations one or two important pieces of apparatus have been invented, and one short paper has been published.

Breeding experiments have been continued with apple and pear seedlings, with a view to securing resistant varieties. Several distinct difficulties have been encountered, not the least of which is that of finding seed of desirable stock and in sufficient quantity for breeding purposes. Much progress was made toward the perfection of a method for inoculating seedlings in the field.

The following projects, under investigation by S. H. Essary, Assistant Botanist and Mycologist, are presented as reported by him:

The experiment with a blight-resistant strain of tomatoes mentioned in previous reports were continued during the year. The strain continues to show a strong resistance to the attacks of *Fusarium* wilt, or blight. Several tomato growers volunteered to test the strain along with plants of the same variety grown from commercial seed, and in all cases strong resistance was shown by the select strain. There still remain the quality of earliness and other desirable characters to be developed, and the work will be continued along these lines this season. Several truckers have been supplied with a sufficient quantity of the seed to give the strain a thorough test. Several strains of the fungus *Fusarium* have been isolated from diseased tomato plants, and are now growing in pure culture in the laboratory. Inoculation experiments are to be undertaken to study the relation of these fungi to tomato diseases.

The breeding experiments with Japan clover mentioned in the last report have been very successful. It appears that there are many strains of this plant, varying as to size, earliness, habit of growth and other characteristics. The experiments will be continued this season, and efforts will be made to improve these strains and to study their adaptation to the various soil and climatic conditions of the State.

It is hoped that a bulletin may be published by the end of the year giving the results of tomato experiments. Probably a preliminary report can be published concerning the Japan clover work.

Respectfully submitted,

SAMUEL M. BAIN, Botanist.

REPORT OF THE CHEMIST AND AGRONOMIST

During the past year three bulletins have been issued from this Department; No. 97, "Liming for Tennessee soils;" No. 101, "The rational improvement of Cumberland Plateau soils," and No. 100, "Soil carbonates: a new method of determination."

No. 97 is a 36-page bulletin, which gives the results of liming experiments on various soils in all three divisions of the State. In East Tennessee most of the work was done either at the Experiment Station at Knoxville or on land a few miles from Knoxville, rented for experimental purposes. The results showed the great practical value of liming not only in the getting of clover and alfalfa but also

in the increasing of the yields of nearly all of the common farm and garden crops. In Middle Tennessee, liming experiments were conducted at various localities, and most of the prominent soil types were included. The Cumberland Plateau section proved to be especially poor in lime. The various soils of the Highland Rim also proved to be deficient in this element, which should be considered as indispensable in their permanent upbuilding. The soils of the Central Basin proved, as might have been expected, to be better supplied with lime than those of any other large area. However, in about three trials out of four, liming proved highly profitable, especially for crops like alfalfa and clover. Much of the past difficulty in getting and maintaining a stand of red clover can undoubtedly be attributed to a deficiency of lime. In West Tennessee the liming experiments were limited to the Experiment Station, at Jackson. Two typical soils were used there, the brown loam and the gray, "crawfishy" silt loam. The brown loam responded remarkably to liming, which was found to be indispensable to success with such crops as clover and alfalfa. Corn, sorghum, cowpeas, soy beans, wheat and oats were materially increased in yield. On the same land, however, cotton was not benefited, and this fact illustrates the marked differences between different crops in their response to the same treatment. Peanuts and tobacco are two other crops which did not appear to be benefited by liming. Rate-of-liming experiments were made on several different farms, and the conclusion was reached that two tons of the ground limestone per acre are ample for the immediate needs of such a crop as alfalfa, which is affected more than any other common crop by a deficiency of lime.

No. 101 is a 40-page bulletin, which relates in particular to the rational improvement of Cumberland Plateau soils, and gives the conclusions reached from six years of field experiments with various farm crops. The Plateau is practically an undeveloped section, of considerable agricultural promise. If its possibilities are to be realized, however, proper methods should be followed in the handling of the soil, which is a fine sandy loam, poor in most of the elements of plant food. The results of the experimental work indicate that only moderate applications of both lime and phosphate are needed to supply this soil with the mineral elements of plant food. In fact, little more is required than may be used profitably on the average soils of the Eastern States. The supply of nitrogen and humus can be materially and practically increased by the growing of legumes, of which red clover is of most importance. The adaptability of these soils and the favorable climatic conditions for the growing of Irish potatoes, trucking crops, and fruits are greatly to the advantage of this section as compared with other parts of the State.

Bulletin No. 100 is a technical publication, which is described later in this report.

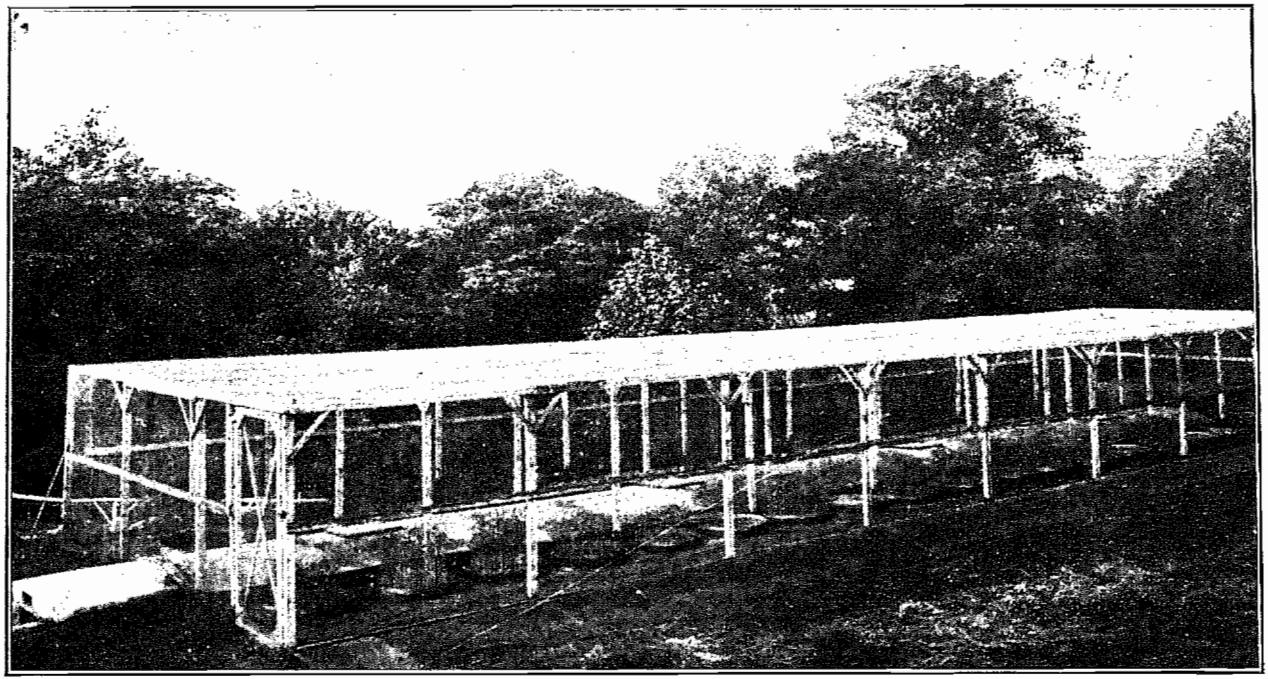
The Middle Tennessee cooperative experiments were begun in 1907, and have been continued up to the present time. Three reports, including Bulletin 101, have been published from this Department. A fourth publication has been prepared, giving in particular the conclusions of six years of soil fertility studies on the Highland Rim. These studies, not only on the Rim, but elsewhere in this division of the State, have been of invaluable aid in determining the fertilizer requirements of large agricultural areas, the system of crop rotation which may be followed to the most advantage, and the best varieties of corn, sorghum, soy beans, etc., for each of the different soil types. Without the results of this work it would be practically impossible to answer satisfactorily the numerous questions which are being received in constantly increasing numbers.

The agronomy work has progressed very satisfactorily at the West Tennessee Station during the past year. The season of 1913 was favorable to practically all crops. The same lines of work as indicated in former reports have been continued. The experiments with various crop rotations have now gone on for five years and many valuable data have been obtained. At this Station variety trials of cotton, and fertilizer and cultural experiments with this crop, have been conducted to much advantage. Previous to the establishment of this Station little attention could be given to this important crop.

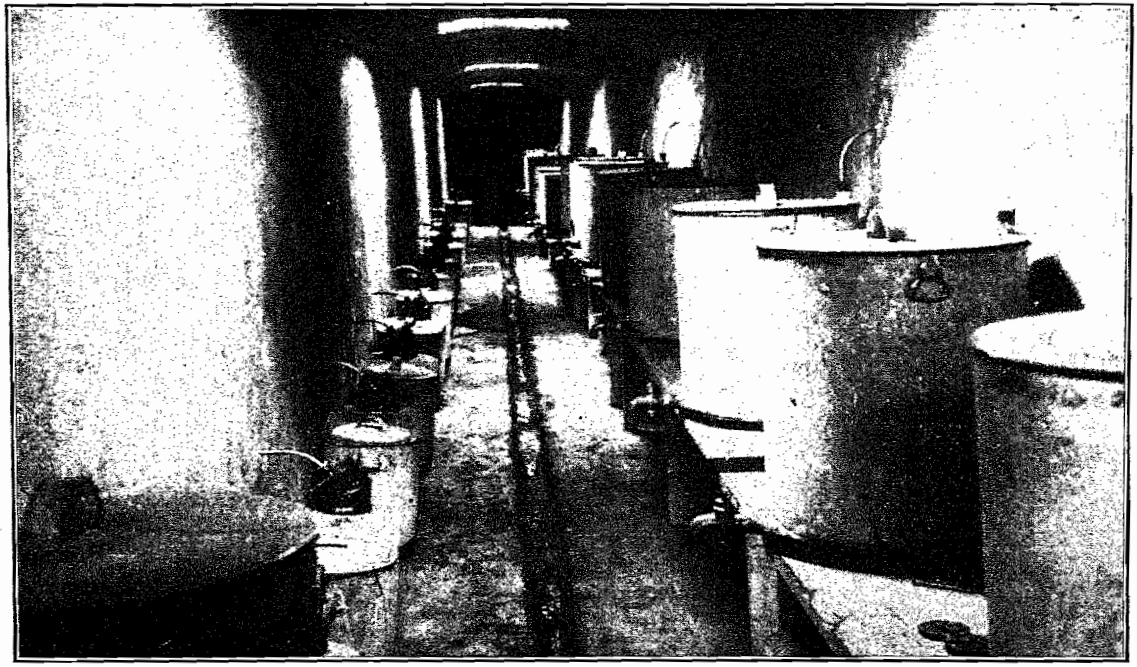
A report of the results of the various field experiments for the past five years is now being prepared. Some of the data have, however, been published in Bulletin 97, to which reference has been made.

In cooperation with the Bureau of Plant Industry of the U. S. Department of Agriculture, and the County of Montgomery, special field experiments and demonstrations in tobacco culture were started in the spring of 1913 at Clarksville, Montgomery County. The work includes fertilizer experiments, rotations with special reference to tobacco, variety trials, cultural demonstrations, etc. The soil used is a typical gray-colored silt soil of that section, and is considered to be well suited to the production of dark-leaved tobacco. The introduction of crops other than tobacco is making the work especially attractive to all concerned.

The investigation of the amount of drainage water obtained under various experimental conditions, including variations in depth of soil and manurial treatment, and the contents of the various plant-food and other elements in the water, was carried on throughout the year. This investigation includes the analyses of the soils for both nitrogen and humus and the determination of nitrogen in the crops grown. The accompanying pictures show both the exterior and interior arrangements of the plant used. At the present time only non-legumes, wheat and millet, one crop of each every year, are grown. The present plan is to continue these crops for a time and then to grow only legumes in order to get some quantitative effects



PIT SYSTEM FOR INVESTIGATION OF SOIL LEACHINGS



INTERIOR VIEW OF PIT, SHOWING TWO FORMS OF CONTAINERS USED

of each family of plants on the fertility of the soil. The surface area of each can is 1/5000 acre. The depth of the cans varies from 1 foot to 6 feet, and three different types of soil are being used, each type representing a large area found in the State.

Experiments in soil fertility by means of cylinders sunk in the ground 4 feet and filled with soil as it was naturally found in the field to that depth, have been continued for four years. One hundred cylinders, each 1/10000 acre in superficial area, are in use. Four typical soils from different parts of the State are under experiment, with the same treatments for each type. Only non-legumes, wheat and millet, have been grown in 69 of the cylinders. In 31 others no crops are grown. The soils were carefully analyzed at the outset for both nitrogen and humus, and the changes in the content of these two constituents under the various conditions are being carefully followed up in the laboratory. The soil treatments consist of various single and combined applications of lime, manure and fertilizer materials.

During the past year special series of experiments to test the effects of various forms of lime and magnesia on the nitrogen and humus contents of the soil were started. A total of 128 rims, each 1/10000 acre in superficial area, were used. Both cropped and uncropped series are being used under various conditions of manuring and mechanical handling.

Soil Laboratory Investigations

In addition to analyses to determine the chemical composition of drainage waters and analyses of crops and soils of field experiments by established official methods, the work of the soil laboratory during the past year has been directed to the perfection of two analytical procedures essential to the investigations under way, and to basket and pot work.

The necessity of accurately determining minute amounts of soil carbonates led to the evolution of a method published by W. H. MacIntire and L. G. Willis as Bulletin No. 100. Essentially the method is based upon the finding that phosphoric acid is less active upon soil organic matter than the mineral acids formerly used, and that all CO_2 can be liberated from solution by aspiration with agitation at room temperature, instead of heating as was formerly held to be necessary. The desirability of relatively large samples for analysis and the need for application of a blank were also established. This method has been made a subject of study by the Association of Official Agricultural Chemists.

The inauguration of further extensive field experiments involving studies of accumulation and depletion of humus made it essential to perfect for the determination of humus a method embodying both

speed and accuracy. This study was made by W. H. MacIntire and J. I. Hardy, and resulted in the new procedure to be published as Bulletin No. 103, under the title, "The influence of ammonium carbonate upon the determination of humus." The procedure for humus makes use of the Buchner funnel for both filtrations and washings. The solvent action of ammonium carbonate was studied as contrasted to its coefficient of occlusion. The use of 1 gram of ammonium carbonate was advocated to facilitate the determination. This amount was found to be sufficient to increase many times the speed of filtration and to lower materially the ash content of the filtrate, but not enough to effect occlusion.

There is also under way an investigation of those factors influencing the determination of the lime requirement of soils by the Veitch method.

As supplementing the laboratory studies of the Veitch method, a comprehensive wire basket experiment was planned. Three types of soil, a Cumberland loam, a Tellico sandy loam, and a silt loam of Chickamauga limestone derivation, were selected for study under fallow and cropping. There were grown three crops, wheat, common red clover, and clover immune to anthracnose. In one set of baskets the amounts of calcium carbonate indicated by the Veitch method were added, and in another set the treatment was supplemented by the addition of the Veitch requirement plus one-third, and in two other sets by the application of two additional excessive amounts of calcium carbonate, representing 1785 and 16070 pounds per acre.

In addition to the laboratory work in connection with the various soil investigations, several hundred samples of limestone have been analyzed for farmers in various parts of the State. This was done in order to encourage the use of ground limestone, so that only that of the highest grade would be utilized. The samples received have represented all grades of rock from those containing little or no lime to those which are strictly high-grade, containing 98 per cent or more of calcium carbonate.

Because of the abundance of magnesium limestone in Tennessee, it was thought advisable to study the magnesium needs of the soils selected. Accordingly there were made treatments of normal magnesium carbonate in molecular equivalents to the amounts used of calcium carbonate. The effects upon plant growth are still under observation and will be reported later.

At the end of one year's period of contact the fallow soils subjected to the heaviest carbonate treatment were analyzed to determine the excess of carbonate present. It was found that a large excess of carbonate of lime existed, but the magnesium carbonate had been entirely dissipated. The observation was substantiated by carbonate determinations in eight instances of field treatment, where contact had extended over a period of eight weeks.

Further laboratory work has shown this dissipation as being due not only to decomposing action of acid silicate, as was formerly held, but to affinity of magnesia for silica. This finding was announced in Science, issue of March 6, 1914, and will be published in detail in bulletin form.

In addition to the regular work outlined in the different projects, J. I. Hardy, under direction of W. H. MacIntire, has done considerable pot work in a study of the lime-magnesia ratio for plants, as a thesis, in part requirement for the degree of M. S.

The volume of the work done and its character have been made possible by the warm and cordial support of the Director of the Station, the zeal and interest of the entire staff, and loyalty among the personnel of the Department.

Respectfully submitted,

C. A. MOOERS, Chemist and Agronomist.

REPORT OF THE HORTICULTURIST

During the year, progress has been made in investigations under way. Interesting results in the summer pruning of the peach warrant the publication of a bulletin on this subject, which will be ready for issue immediately. By the summer-pruning of the new growth before the middle of June, fruiting wood for the succeeding year can be had the entire length of the skeleton branches of the trees, thus making it possible to reduce the height of the trees greatly, while providing for a full crop. A little care will provide two sets of young growth, one of which will bear the current season, and the other in the following year, the two fruiting in alternate years. In this way the trees are kept low, making spraying and harvesting much easier.

The investigation of the rooting system of the apple tree in different soils continues. This work is necessarily slow, requiring skill in excavating the roots and in platting their direction. The apple tree grown in shallow soil (shale rock 2½ to 3 feet below the surface) spreads its roots far beyond the periphery of its crown, the main roots lying closer to the rock stratum than to the surface. It is hoped to lay bare the root system of a tree growing in very deep loam during the coming summer.

Experiments to determine best rotations for truck crops, and other trucking investigations, are under way.

During the year Mr. Russell G. Briggs, of the University of Missouri, came to the Department as Assistant Horticulturist.

Respectfully submitted,

CHARLES A. KEFFER, Horticulturist.

REPORT OF THE ANIMAL HUSBANDMAN

During the past year the Experiment Station has had more animals on experiment than in any previous year. There were 48 experimental groups of cattle and hogs. The total number of steers on experiment was 328, of which 273 were fed at the West Tennessee Experiment Station under the supervision of S. A. Robert, the Superintendent. The experimental work at the West Tennessee Station with beef cattle was divided into two general groups; namely, finishing steers and wintering stocker steers. There were on full feed 231 steers, divided into 21 groups.

The rations tested at the West Tennessee Station for the year were as follows:

Table of rations for finishing experiments

Lot No.	No. of Steers	Ration per head per day
I	8	Silage; .....3, 4, 5 lbs. Cottonseed meal
II	8	Silage; .....5, 6, 7 " " "
III	8	Silage; .....7, 8, 9 " " "
IV	8	Cottonseed hulls; 3, 4, 5 " " "
V	8	" " 5, 6, 7 " " "
VI	8	" " 7, 8, 9 " " "
VII	8	" " 7, 8, 9 " " " iron sulphate, 1 lb. for every 50 lbs. of cottonseed meal.
VIII	8	Cottonseed hulls; 10 lbs. silage; 5, 6, 7 " " "
IX	8	Cottonseed hulls; 1 lb. cottonseed meal 45 days; 5, 6, 7 lbs. cottonseed meal 45 days in 15-day periods
X	8	Cottonseed hulls; 1 lb. cottonseed meal 45 days; 10, 11, 12 lbs. cottonseed meal 45 days, in 15-day periods
XI	8	Cottonseed hulls; 2 lbs. cottonseed meal 45 days; 5, 6, 7 lbs. cottonseed meal 45 days, in 15-day periods
XII	8	Cottonseed hulls; 2 lbs. cottonseed meal 45 days; 9, 10, 11 lbs. cottonseed meal 45 days, in 15-day periods
XIII	16	Cottonseed hulls; 5 lbs. silage; 5, 6, 7 lbs. cottonseed meal
XIV	15	Cottonseed hulls 26 days; then silage 4 days; 5, 6, 7 lbs. cottonseed meal
XV	12	Silage; 6, 10, 14 lbs. ear corn; 6, 5, 4 lbs. cottonseed meal. Hogs following
XVI	12	Silage; 6, 10, 14 lbs. ear corn; 4, 5, 6 lbs. cottonseed meal. Hogs following
XVII	24	Cottonseed hulls; 3, 4, 5 lbs. cottonseed meal, in 15-day periods 7, 8, 9 lbs. cottonseed meal, in 15-day periods
XIX	16	Cottonseed hulls; 3, 4, 5 lbs. cottonseed meal, in 40-day periods
XX	12	Cottonseed hulls; 6, 10, 14 lbs. ear corn; 3, 4, 5 lbs. cottonseed meal. Hogs following
XXI	12	Cottonseed hulls; 6, 10, 14 lbs. ear corn; 5, 6, 7 lbs. cottonseed meal. Hogs following

The length of feeding for each group except XIX was 90 days, divided into three 30-day periods each unless otherwise stated. Where comparisons were made between high, medium and low amounts of cottonseed meal the results were similar to those of former years, in that the most economical gains were made with the medium amounts of the meal and that heavy feeding of the meal was not so profitable as the feeding of medium amounts. Silage was more efficient than hulls.

The experiments on the wintering of stocker steers at the West Tennessee Station are being carried on with the object of determining the best method of wintering stockers. All the groups are turned on the same pasture for the summer, and complete data for one year are made. The rations for the winter feeding were as follows:

Table of rations for stocker experiments

Lot No.	No. of steers	Ration per head per day	Shelter
I	5	Cottonseed hulls; 2 lbs. cottonseed meal	Outdoors
II	5	Corn stover; 1 lb. cottonseed meal	Outdoors
III	5	Corn stover; 1 lb. cottonseed meal	Indoors
IV	5	Straw; 2 lbs. cottonseed meal	Outdoors
V	5	Straw; 1 lb. cottonseed meal	Outdoors
VI	5	Cottonseed hulls; ½ lb. cottonseed meal	Indoors
VII	5	Straw; 1 lb. cottonseed meal	Indoors
VIII	5	Silage; no meal	Indoors

At the Knoxville Station the steer-acre experiments have been continued. Five years' data have now been obtained on the amount of beef an acre of land will produce with various crop rotations. The rotations on the acres are as follows:

Table of rotations

Acre No.	Rotation
I	Barley and soy beans. Both taken off as grain
II	Barley and cowpeas. Both taken off as grain
III	Barley and corn. Both taken off as grain
IV	Barley and soy beans. Barley taken off as grain and soy beans as hay
V	Wheat and soy beans. Both taken off as grain
VI	Oats and soy beans. Both taken off as grain
VII	Alfalfa hay

During the past year experiments were conducted to show the effect of iron compounds when fed with cottonseed meal to hogs. The rations fed were as follows:

Table of rations for hog-feeding experiments

Lot No.	No. of hogs	Ration per head per day
I	3	4 parts corn meal 1 part cottonseed meal
II	3	4 parts corn meal 1 part cottonseed meal 1 lb. iron sulphate for every 50 lbs. cottonseed meal
III	3	4 parts corn meal 1 part cottonseed meal 1 lb. iron chloride for every 50 lbs. cottonseed meal
IV	3	2 parts corn meal 1 part cottonseed meal
V	3	2 parts corn meal 1 part cottonseed meal 1 lb. iron chloride for every 50 lbs. cottonseed meal

All the shoats on experiment did well for the first three weeks, but later two of the shoats in Lot IV died, and the shoats in Lot I made practically no gains. The shoats in Lots I and IV that did not die became very much emaciated. The shoats in Lots II, III and V made good gains and were not affected detrimentally by the cottonseed meal.

These experiments were suggested as a result of work done by Dr. W. A. Withers, of the North Carolina Experiment Station. It would seem that cottonseed meal can safely be fed to hogs when some iron compound, such as copperas (iron sulphate) is fed with the meal at the rate of one pound for every 50 pounds of cottonseed meal fed.

Cooperative poultry breeding work is being conducted with Mr. J. A. Dinwiddie, New Market, Tenn. The object of the experiment is to isolate high egg-laying strains of poultry by the selection of cock birds whose offspring possess high egg-laying qualities.

Cooperative feeding work with steers is being conducted in Middle Tennessee. The field work is under the immediate supervision of L. R. Neel. The influence of the sire upon the offspring is being determined through breeding experiments conducted upon the breeding herd at Knoxville. The dairy herd is headed by three high-class Jersey sires, whose offspring are being tested.

Respectfully submitted,

C. A. WILLSON, Animal Husbandman.

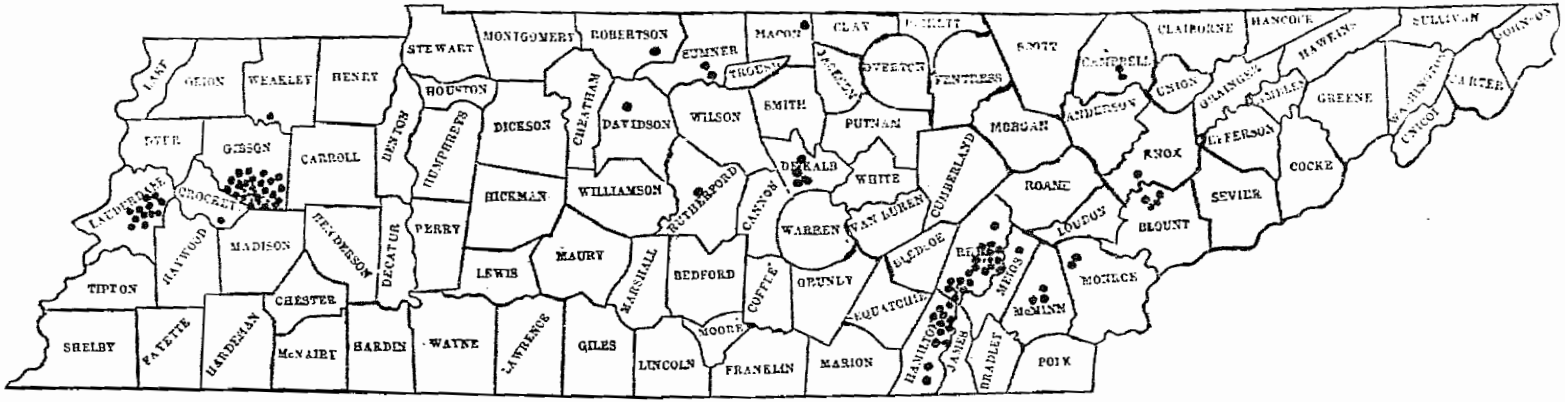
REPORT OF THE ASSISTANT ZOOLOGIST AND ENTOMOLOGIST

Following is a brief report of the Assistant Zoologist and Entomologist for the year 1913:

The farmer, the orchardist, the nurseryman, and the cotton and tobacco growers in Tennessee, more than ever before, are directing their attention to the protection of their crops from preventable loss due to insect pests. Thus it will be seen that the great interests for which Tennessee is noted are in a large measure dependent upon the investigation of insect life-histories, and advice as to practical methods of controlling injurious insects and of protecting those of beneficial nature.

The quarantined strawberry pest, the root-louse (*Aphis forbesi* Weed), has continued to spread since the inspections were made a year ago. It has now been found in 18 counties of the State, viz., Blount, Campbell, Crockett, Davidson, DeKalb, Gibson, Hamilton, Knox, Lauderdale, McMinn, Macon, Meigs, Monroe, Rhea, Robertson, Rutherford, Sumner and Weakley; the degree of infestation ranging from 5 to 85 per cent. During the fall of 1913, after a continued dry, late season, many of the lice found upon the leaves and stems were parasitized by *Aphidius testaceipes*. In one case in particular, in Hamilton County, the high degree of parasitism was a means of controlling the aphis above ground. Several infested fields of strawberries were inspected late in December in the eastern part of the State, and many eggs were found attached to the leaf-stem; active aphids were also found on the leaves and stems. Up to that time, however, there had been little or no cold weather. For the year 1913 we have recorded 101 different strawberry fields in which the root louse is present. This insect will be studied further, and investigations will be made in regard to its life-history, and measures taken to prevent further dissemination. Since the publication of the last report, many inquiries have been received in regard to this strawberry pest. Several articles have been printed in the papers of the State for the purpose of acquainting the people with this insect so that they may not introduce it in making new plantings of strawberries. The accompanying map shows the locations where the strawberry root louse has been found during the present year.

In six different parts of the State, cooperative experiments are being carried on under the direction of the Station Entomologist. Three of these experiments are with insecticides, and three on insect life-histories. The results obtained from these experiments will prove of great value, for at present we have no dependable data on these special subjects of study. As our county correspondents become better acquainted with insect life it is hoped that one or more cooperative experiments may be conducted in each county of the State.



BLACK DOTS SHOW STRAWBERRY ROOT-LOUSE INFESTATION

An accession file is kept in the office of the Entomologist, containing the names of all insects, both of injurious and beneficial nature, concerning which information has been sought. These data regarding the occurrence of insects, where and when found, amount of injury, remedy prescribed, and names of persons seeking information, furnish material for bulletins and for circular letters to the press in the communities where insect pests are causing preventable loss.

The injury resulting from insects is different in different years, due to climatic conditions, which may cause either the absence or the presence of natural parasites. In 1913 the greatest number of complaints and injuries have been received concerning the following insects: Corn ear-worm, grape scale, bee moth, grasshopper, corn budworm, oyster-shell scale, ox bot fly or "warbles," hog louse, plant lice on turnips, ants in lawns, stored-grain insects, apple aphis, spring grain louse or "green bug," black peach aphis, San Jose scale, potato beetle, striped and spotted cucumber beetle, pickle worm, squash vine borer, squash bug, melon plant louse, and strawberry root-louse.

The observations made by the county correspondents have been the means of keeping the Station in touch with the existing conditions relative to insect attacks in the different parts of the State. Blanks have been sent out monthly to the county correspondents for records of their observations, and these correspondents are competent persons, who are interested in their county's welfare and are willing to offer their services with a view to keeping the Station in touch with insect outbreaks in the different parts of the State. The number of county correspondents at present is 168, distributed in the counties as follows:

Anderson 3, Bedford 6, Benton 5, Bledsoe 4, Blount 8, Bradley 7, Campbell 8, Cannon 5, Carroll 2, Carter 1, Cheatham 2, Chester 1, Claiborne 3, Cocke 1, Crockett 1, Cumberland 1, Davidson 3, DeKalb 2, Dickson 1, Dyer 1, Fayette 1, Fentress 2, Franklin 1, Gibson 3, Giles 1, Grainger 1, Greene 2, Grundy 1, Hamblen 2, Hamilton 2, Hancock 1, Hardeman 1, Hawkins 2, Haywood 1, Henderson 1, Henry 1, Houston 1, Jackson 1, James 1, Jefferson 2, Johnson 1, Knox 2, Lauderdale 1, Lawrence 1, Lewis 1, Lincoln 3, Loudon 1, McMinn 2, McNairy 1, Madison 4, Marshall 2, Maury 5, Meigs 1, Monroe 2, Montgomery 3, Moore 1, Morgan 1, Obion 3, Overton 1, Perry 2, Pickett 1, Polk 1, Putnam 1, Rhea 3, Roane 1, Robertson 1, Rutherford 1, Scott 1, Shelby 2, Smith 1, Sullivan 1, Sumner 4, Tipton 1, Unicoi 2, Union 2, Van Buren 2, Warren 1, Washington 5, Wayne 3, Weakley 1, White 1, Wilson 1.

During the past year two bulletins have been written dealing with insects and methods for their control; Bulletin 98, "The San Jose scale in Tennessee with methods for its control," and Bulletin 99, "Suggestions on preparation and use of spray formulas."

By becoming acquainted with the habits of insects and methods for their control, the farmer, fruit grower and trucker will be able to save the greater part of an estimated $10,000,000 annual loss from insects, and to secure such legislation with reference to the destruction or preservation of insects as will be to the best interests not only of the present but of future generations.

Respectfully submitted,

G. M. BENTLEY, Assistant Zoologist and Entomologist.

REPORT OF THE BACTERIOLOGIST

The central problem upon which the Department of Bacteriology has been largely engaged during the year is that of the interrelation of bacteria and the decayed and decaying matter encountered in the soil, usually referred to as humus. At the outset it was thought necessary to produce conditions which would enable the experimenter to govern as far as possible the various factors that seem to be involved in the production of humus from raw organic matter. It is of course generally conceded that microorganisms are prime factors in the processes of decay which are supposed to result in humus. Temperature, moisture, and air are thought of as contributory to the bacterial activities. An effort was made, therefore, to assemble equipment that would admit of absolute control of the species of bacteria which were to be allowed to produce decomposition and at the same time supply the requisite air and moisture. To this end, a flask of special design was constructed, which would allow the introduction of sterile water at will and aspiration as desired. This device passed through many stages and was variously modified to insure easy and perfect regulation. The present form is but a slight variation from that given in the Experiment Station Report of 1910.

Specialized features of the general problem of bacteria in relation to humus have been studied in considerable detail. These may be referred to two rather distinct lines of thought; first, the ability of bacteria to produce humus from definite forms of organic matter; second, the effect of humus on nitrogen-assimilating bacteria.

The original assumption was that raw organic matter did not contain anything extractable with 4 per cent ammonia. It seemed quite possible, therefore, to use an inert substance which had been freed from humus by extraction with ammonia as a medium. If this medium were mixed with organic matter and the proper kinds of bacteria were insured a transformation of organic matter to humus should take place, so that the percentage of gain of extractable substance might be determined.

Using the above stated assumption as a working hypothesis, it seemed possible to control conditions so that definite amounts of

humus might be accumulated at will. It would be necessary only to vary the amount of organic matter in its ratio to the inert medium in which the humification is to take place.

To test the possibility of thus forming humus under known conditions, 72 flasks were arranged in two series of 36 flasks each. These flasks were supplied with 500 grams of humus-free sand plus organic matter in the form of cottonseed meal and ground straw in one series and cow dung in the other. Mineral matter thought to be most favorable to bacterial growth in general was added to all flasks. The flasks were set up in groups of 6 each according to the variation of the amount of organic matter, so that for each given amount there were 6 with like treatment. All flasks were supplied with water at 60 per cent saturation and sterilized. Five flasks in each group were inoculated with a soil extract; one being left sterile throughout the experiment. After six months the analyses for humus were made, and it was found that those having the greatest amount of organic matter originally supplied yielded the most humus. There was almost a constant gradation as the organic matter increased. It was observed, however, that the flasks which remained sterile gave always as much humus as those in which bacterial action had been allowed to take place, and often more.

At this point 36 other flasks were arranged as above described and received the organic matter as cow dung. Results here were practically identical with those of the first two series so far as the ratio of organic matter to humus was concerned. This raised the question as to the ammonia-extractable substance in the raw matter, and another series of 18 flasks was introduced to test this proposition. Three of these received the sand, organic matter, and minerals, but were analyzed immediately without sterilization. Three were sterilized and analyzed at once. The other 12 were allowed to stand six months, 6 sterile and 6 inoculated with a soil extract.

Results of analyses showed slightly more humus in the raw material than in the flasks which had been sterilized and allowed to stand either sterile or inoculated. Sterilization within itself seemed to decrease the extractable matter. Bacteria certainly did not accumulate humus in the flasks into which they were introduced.

Nitrogen determinations of the contents of these flasks showed a decided loss in those which had been inoculated. In brief, therefore, under the conditions maintained organic matter in the inoculated flasks is decomposed, nitrogen is liberated, but humus is not produced.

The second feature of the work mentioned above is concerned with the effect of humus on nitrogen assimilation by *Azotobacter*, and involves the question of its formation under control. It is obviously impossible to secure varying percentages of humus in normal soils and maintain a constancy of other factors which might easily influence the

activity of the nitrogen-assimilating bacteria. It is likewise impossible to secure humus in such purity that it might be added in given quantities to a medium used for nitrogen-assimilating bacteria. The necessity is presented, therefore, of accumulating it under uniform conditions. As has been seen above, our present methods do not enable us to do this.

During the year some attention has been given to the morphological and physiological characteristics of *Azotobacter vinelandii.*

The associative action of *Azotobacter*, *Bacillus radicicola* and *Bacillus subtilus* in nitrogen assimilation has been observed, and the results so far indicate that where the three work together more nitrogen is added to the mannite solution than when acting in any other combination. This line of investigation will be continued and extended.

Respectfully submitted,

MAURICE MULVANIA, Bacteriologist.

REPORT OF THE CONSULTING METEOROLOGIST

The total rainfall for Tennessee in 1913 was only one inch below the yearly normal, but the distribution was such that its efficiency was far below the average. The accompanying chart shows the rainfall for Tennessee in 1913 compared with the normal rainfall. The solid line represents the normal, or average, rainfall, while the broken line represents the rainfall in 1913. As the distribution of the rainfall is different in different portions of the State, four charts are given for the four areas shown in the accompanying map.

The greater portion of the State had a wet winter and an early spring, followed by the driest growing season on record.

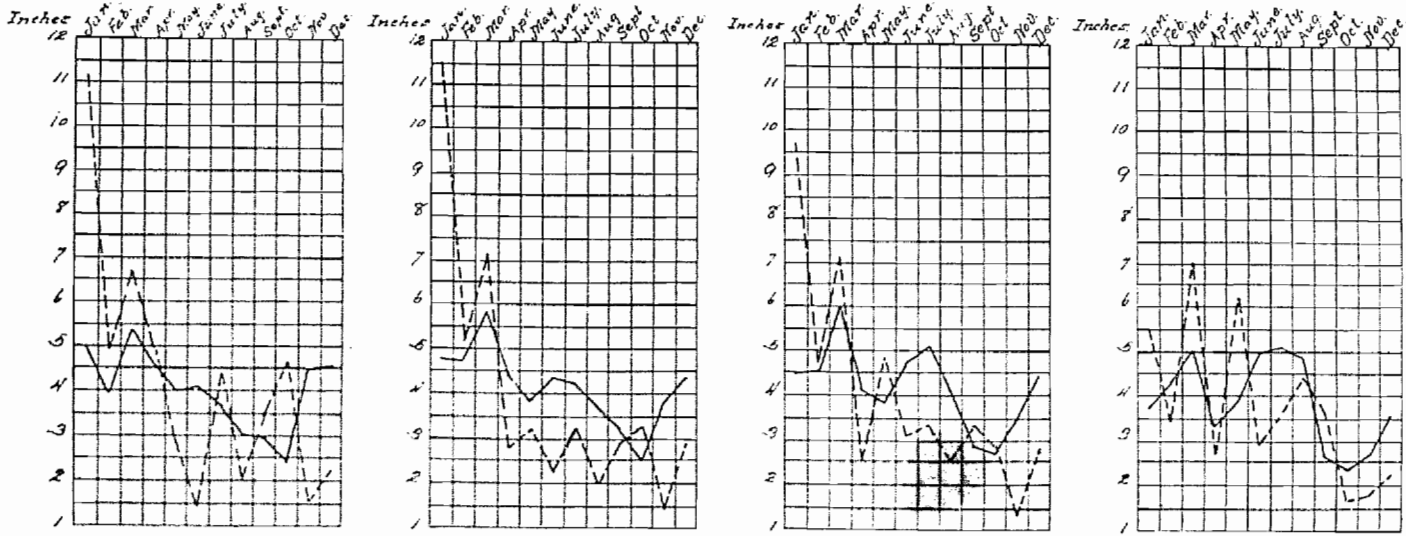
This year's experience simply repeats the lesson of previous years. There is a difference, of course, for there never were two years just alike, but the difference is like that between variations of a familiar piece of music. No matter how great the variation the same air runs through them all. So this year's record of rainfall sings the same old song in a little different way. It tells us again, louder, perhaps, than ever before, the need for deep tillage, humus, and a cover crop for catching, conserving and using the rainfall.

The collection of data for the further study of the relation between weather conditions and the growth of plants was continued through the year.

Recpectfully submitted,

J. F. VOORHEES, Consulting Meteorologist.

1. Clarksville Type 2. Nashville Type. 3. Mc. Minnville Type. 4. Bristol Type.



Four Types of Rainfall (Broken line = rainfall for 1913.)

Areas covered by four types of rainfall

REPORT OF THE LIBRARIAN

Library

Bound volumes	4,794
Accessions during the year	169
Purchased	15
Obtained by exchange and gift	73
Bound by the Station	81
Volumes complete, ready for binding	70
Journals subscribed for	37
Agricultural papers received in exchange for bulletins	128

Mailing List

U. S. Dept. of Agr. and Exp. Stations	2,150
Tennessee newspapers	197
Exchange list	235
Individuals in Tennessee	10,700
Other states	507
Foreign, other than exchanges	85
	13,874

Respectfully submitted,

F. H. BROOME, Librarian.